E. CHUM SALMON

E.1 BACKGROUND AND HISTORY OF LISTINGS

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Chum salmon (*Oncorhynchus keta)* are semelparous, spawn primarily in freshwater, and apparently exhibit obligatory anadromy, as there are no recorded landlocked or naturalized freshwater populations (Randall et al. 1987). The species is known for the enormous canine-like fangs and striking body color (a calico pattern, with the anterior two thirds of the flank marked by a bold, jagged, reddish line and the posterior third by a jagged black line) of spawning males. Females are less flamboyantly colored and lack the extreme dentition of the males.

The species has the widest natural geographic and spawning distribution of any Pacific salmonid, primarily because its range extends further along the shores of the Arctic Ocean than other salmonids. Chum salmon have been documented to spawn from Korea and the Japanese island of Honshu, east, around the rim of the North Pacific Ocean, to Monterey Bay in California. Presently, major spawning populations are found only as far south as Tillamook Bay on the Northern Oregon coast. The species' range in the Arctic Ocean extends from the Laptev Sea in Russia to the Mackenzie River in Canada. Chum salmon may historically have been the most abundant of all salmonids: Neave (1961) estimated that prior to the 1940s, chum salmon contributed almost 50% of the total biomass of all salmonids in the Pacific Ocean. Chum salmon also grow to be among the largest of Pacific salmon, second only to chinook salmon in adult size, with individual chum salmon reported up to 108.9 cm in length and 20.8 kg in weight (Pacific Fisherman 1928). Average size for the species is around 3.6 to 6.8 kg (Salo 1991).

Chum salmon spend more of their life history in marine waters than other Pacific salmonids. Chum salmon, like pink salmon, usually spawn in coastal areas, and juveniles out migrate to seawater almost immediately after emerging from the gravel that covers their redds (Salo 1991). This ocean-type migratory behavior contrasts with the stream-type behavior of some other species in the genus *Oncorhynchus* (e.g., coastal cutthroat trout, steelhead, coho salmon, and most types of chinook and sockeye salmon), which usually migrate to sea at a larger size, after months or years of freshwater rearing. This means survival and growth in juvenile chum salmon depends less on freshwater conditions than on favorable estuarine conditions. Another behavioral difference between chum salmon and species that rear extensively in freshwater is that chum salmon form schools, presumably to reduce predation (Pitcher 1986), especially if their movements are synchronized to swamp predators (Miller and Brannon 1982).

In December 1997 the first ESA status review of west coast chum salmon (Johnson et al. 1997) was published which identified four ESU: 1) Puget Sound/Strait of Georgia ESU, which includes all chum salmon populations from Puget Sound, the Strait of Georgia, and the Strait of Juan de Fuca up to and including the Elwha River, with the exception of summer-run chum salmon from Hood Canal; 2) Hood Canal summer-run ESU, which includes summer-run populations from Hood Canal and Discovery and Sequim Bays on the Strait of Juan de Fuca; 3) Pacific coast ESU, which includes all natural populations from the Pacific coasts of California,

Oregon, and Washington, west of the Elwha River on the Strait of Juan de Fuca; and 4) Columbia River ESU.

In March 1998, NMFS published a federal register notice describing the four ESUs and proposed a rule to list two--Hood Canal summer-run and Columbia River ESUs--as threatened under the ESA (NMFS 1998). In March 1999, the two ESUs were listed as proposed, with the exception that the Hood Canal summer-run ESU was extended westward to include summer-run fish recently documented in the Dungeness River (NMFS 1999a).

The NMFS convened a BRT to update the status of listed chum salmon ESUs coastwide. The chum salmon BRT[1] met in January, March and April 2003 in Seattle, Washington to review updated information on each of the ESUs under consideration.

[1] The Biological Review Team (BRT) for the updated chum salmon status review included, from the NMFS Northwest Fisheries Science Center: Tom Cooney, Dr. Robert Iwamoto, Dr. Robert Kope, Gene Matthews, Dr. Paul McElhany, Dr. James Myers, Dr. Mary Ruckelshaus, Dr. Thomas Wainwright, Dr. Robin Waples, and Dr. John Williams; from the NMFS Southwest Fisheries Science Center: Dr. Peter Adams, Dr. Eric Bjorkstedt, and Dr. Steve Lindley; from the NMFS Alaska Fisheries Science Center (Auke Bay Laboratory): Alex Wertheimer; and from the USGS Biological Resource Division: Dr. Reginald Reisenbichler.

E.2.1. HOOD CANAL SUMMER-RUN CHUM SALMON

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E.2.1.1. Summary of Previous BRT Conclusions

The status of Hood canal summer-run chum salmon was formally assessed during a coastwide status review (Johnson et al. 1997). In November 1998, a BRT was convened to update the status of the ESU by summarizing information received since that review and comments on the 1997 status review, summarize, and present BRT conclusions concerning ESU delineation and risk assessment for chum salmon in Washington, Oregon, and California (NMFS 1999b).

Status and trends

In 1994, petitioners identified 12 streams in Hood Canal as recently supporting spawning populations of summer-run chum salmon. At the time of the petition, summer-run chum salmon runs in five of these streams may already have been extinct, and those in six of the remaining seven showed strong downward trends. Similarly, summer-run chum salmon in Discovery and Sequim Bays were also at low levels of abundance. Spawner surveys in 1995 and 1996 revealed substantial increases in the number of summer-run chum salmon returning to some streams in Hood Canal and the Strait of Juan de Fuca. However, serious concerns remained (Johnson et al. 1997). First, the population increases in 1995 and 1996 were limited to streams on the western side of Hood Canal, especially the Quilcene River system, while streams on the southern and eastern sides of Hood Canal continued to have few or no returning spawners. Second, a hatchery program initiated in 1992 was at least partially responsible for adult returns to the Quilcene River system. Third, the strong returns to the west side streams were the result of a single, strong year class, while declines in most of these streams have been severe and have spanned two decades. Last, greatly reduced incidental harvest rates in recent years probably contributed to the increased abundance of summer-run chum salmon in this ESU. Spawning escapement to the ESU was estimated to be 10,013 fish in 1997 and 5,290 fish in 1998. Of these totals, 8,734 spawners in 1997 and 3,959 spawners in 1998 returned to streams with supplementation programs.

Previously reported threats

A variety of threats to the continued existence of the summer-run chum salmon populations in Hood Canal were identified in the status review (Johnson et al. 1997), including degradation of spawning habitat, low river flows, possible competition among hatchery fall chum salmon juveniles and naturally produced summer-run chum salmon juveniles in Hood Canal, and high levels of incidental harvest in salmon fisheries in Hood Canal and the Strait of Juan de Fuca.

Previous BRT conclusions

The status of the Hood Canal summer-run chum salmon ESU was last reviewed in November 1998, where they concluded that the ESU was likely to become endangered in the

foreseeable future. The primary concerns of the BRT relating to ESU status were low current abundance relative to historical, extirpation of historical populations on the eastern part of Hood Canal, declining trends, and low productivity. Other concerns included the increasing urbanization of the Kitsap Peninsula, recent increases in pinniped populations in Hood Canal, and the fact that recent increases in spawning escapement have been associated primarily with hatchery supplementation programs. Concerns were mitigated to some extent by recent reforms in hatchery practices for fall chum salmon and measures taken by the state and tribes to reduce harvest impacts on summer-run chum salmon.

Listing status—Threatened

E.2.1.2 New Data and Updated Analyses

ESU status at a glance

Historical peak abundance	N/A
Historical populations	16
Extant populations	8
1999-2002 geometric mean escapement per extant population	10 – 4,500
1999-2002 arithmetic mean escapement per extant population	52 – 4,700
recent (1990-2002) trend per extant population	0.82 – 1.62 (median = 1.17)
long-term trend per extant population	0.88 – 1.08 (median = 0.94)

ESU structure

The Hood Canal summer-run chum salmon ESU is comprised of 16 historically independent populations, eight of which are presumed to be extant currently (Table E.2.1.1). Most of the extirpated populations occur on the eastern side of Hood Canal, and some of the seven putatively extinct stocks are the focus of extensive supplementation programs underway in the ESU (WDFW and PNPTT 2000 and 2001).

Table E.2.1.1. Historical populations of summer-run chum salmon in the Hood Canal ESU (WDFW and PNPTT 2001).

Stock	Status
Union River	Extant
Lilliwaup Creek	Extant
Hamma Hamma River	Extant
Duckabush River	Extant
Dosewallips River	Extant
Big/Little Quilcene River	Extant
Snow/Salmon Creeks	Extant
Jimmycomelately Creek	Extant
Dungeness River	Unknown
Big Beef Creek	Extinct
Anderson Creek	Extinct
Dewatto Creek	Extinct
Tahuya River	Extinct
Skokomish River	Extinct
Finch Creek	Extinct
Chimacum Creek	Extinct

The Hood Canal summer-run chum salmon are part of an extensive rebuilding program developed and implemented since 1992 by the state and tribal co-managers (WDFW and PNPTT 2000 and 2001.) The Summer-run Chum Salmon Conservation Initiative involves six supplementation and two reintroduction projects. The largest supplementation program occurs at the Big Quilcene River fish hatchery, and beginning with the 1997 brood year, all fry from the Quilcene facility have been adipose-fin-clipped. Summer-run chum salmon hatchery fish in Salmon Creek have been thermally marked since 1992, and other supplementation programs in Hood Canal recently have instigated thermal mass-marking of otoliths for distinguishing hatchery- from natural-origin spawners. Reintroduction programs have been initiated in Big Beef and Chimacum creeks. Small numbers of marked fish collected in streams (i.e., $\leq$ 3 per stream) over the 1999-2000 season indicate that some straying of summer-run chum salmon from the Big Quilcene River supplementation program is occurring into other Hood Canal streams (WDFW and PNPTT 2001).

The methods for summary statistics reported below are described in the Methods section of this report. We report summary statistics only for the 8 extant populations of summer-run chum salmon in Hood Canal—where information is available, a few additional populations experiencing hatchery reintroductions or natural recolonization are included in some tables for completeness. More detailed information on the sources, data years and nature of the information reported below is summarized for each population in Appendix A.5.2.

Abundance of natural spawners

Recent 4-year (1999-2002) geometric mean abundance of summer-run chum salmon in Hood Canal streams containing extant populations ranges from 10 to just over 4,500 spawners (median = 576, mean = 1,064) (Table E.2.1.2; Figure E.2.1.1). Estimates for the fraction of hatchery fish in the combined Quilcene and Salmon/Snow populations are as high as 28 - 51%,

indicating that the supplementation program is resulting in spawners in streams (Table E.2.1.2). In addition to the supplementation programs, reintroduction of hatchery fish to previously occupied streams is occurring in Big Beef and Chimacum creeks. Recent geometric mean escapements from those programs are 17 and 198 adults respectively (over 800 adults in a single year returned to each stream), suggesting that hatchery juveniles released several years ago are successfully returning as adults to spawn.

The 8 extant summer-run chum salmon stocks in Hood Canal are spawning in 13 streams that occur primarily on the western side of Hood Canal. The spatial distribution of the summer-run chum salmon populations in Hood Canal is being extended through reintroduction programs in Big Beef and Chimacum creeks, and through an apparent natural re-colonization in the Dewatto River (J. Ames, WDFW, pers. comm.).

Table E.2.1.2. Abundance and estimated fraction of hatchery fish in natural escapements of Hood Canal summer-run chum salmon spawning populations. (Data are from WDFW and PNPTT 2000, 2001, 2003; Puget Sound TRT, unpublished data).

Population	**Current status**	**Recent 4-year geometric mean escapement (min- max) (1999-2002)**	**Recent 4-year arithmetic mean escapement (1999-2002)**	**% hatchery in natural escapement (1995-2001)**
Jimmycomelately[4]	Extant	10 (1-192)	52	NA
Salmon[1]/Snow	Extant	1,521 (463-5,921)	2,441	0-69
Combined Quilcene	Extant	4,512 (3,065-6,067)	4,665	5-51
Lilliwaup[1]	Extant	13 (1-775)	202	NA
Hamma Hamma[3]	Extant	558 (173-2260)	783	NA
Duckabush	Extant	382 (92-942)	507	NA
Dosewallips	Extant	919 (351-1,627)	1,057	NA
Union[5]	Extant	594 (159-1,426)	769	NA
Chimacum	Extinct, reintroduction	198 (0-903)	464	100 (>1999)
Big Beef[2]	Extinct, reintroduction	17 (0-826)	376	100 (>1999)
Dewatto	Extinct, natural recolonization	9 (2-32)	14	NA

[1]supplementation program began in 1992; recent low spawner numbers in Lilliwaup due in part to large fraction of return used for broodstock (J. Ames, WDFW, pers. comm.)
[2]reintroduction program began in 1996
[3]supplementation program began in 1997
[4]supplementation program began in 1999; recent low spawner numbers due in part to large fraction of return used for broodstock (J. Ames, WDFW, pers. comm.)
[5]supplementation program began in 2000

Trends in natural spawners

Long-term trends in abundance for extant naturally spawning populations of summer-run chum salmon in Hood Canal both indicate that only two populations (combined Quilcene and Union rivers) are increasing in abundance over the length of available time series (Table E.2.1.3). The median long-term trend over all populations is 0.94, indicating that most

populations are declining at a rate of 6% per year. The range in long-term trend across the extant populations in Hood Canal is from 0.88 in the Jimmycomelately and Lilliwaup populations to 1.08 in the Union population. The Quilcene population's positive growth rate is almost surely due to the supplementation program that has been active on that stream.

In contrast to long-term trends, most of the naturally spawning populations of Hood Canal summer-run chum salmon exhibit increasing abundance over the short term—7 of 8 extant populations in the ESU have been increasing in abundance from 1990-2002 (Table E.2.1.3). These recent increases in abundance likely are a reflection of the supplementation programs in some streams and possibly recent improvements in ocean conditions. Short-term median population growth rates (λ) were calculated under two assumptions about the reproductive success of naturally spawning hatchery fish: the reproductive success was 0 (i.e., HO), or the reproductive success was equal to that of wild fish (i.e., H1). Differing assumptions about the reproductive success of hatchery fish only affected calculations of short-term λ for 2 populations because of the dearth of information on the fraction of hatchery fish in time series (Table E.2.1.3). The median short-term λ (1.18) and short-term trend (1.17) over all populations are very similar. The most impressive short-term increase in natural spawner abundance has occurred in the Quilcene population (trend = 1.62, λ = 1.39), where the supplementation program appears to be succeeding in returning natural spawners to the Big and Little Quilcene rivers. The only population with a declining short-term trend and growth rate is the Lilliwaup, where many of the returning spawners have been collected for broodstock in the supplementation program.

Table E.2.1.3. Estimates of long- and short-term trend, short-term median population growth rate ( ), and their 95% confidence intervals for natural spawners in extant Hood Canal summer-run chum salmon populations (data are from the WDFW and PNPTC, unpublished data). Short-term is calculated assuming the reproductive success of hatchery-origin spawners is equivalent to that of wild-origin spawners (in cases where information on hatchery fish is available).

Population	**Data years**	**LT Trend (CI)**	**ST Trend (CI) (1990-2002)**	**ST λ ($\pm$ lnSE) (1990-2002)** [1]
Combined Quilcene	1974 - 2002	1.05 (0.96-1.16)	1.62 (1.31-2.01)	1.39 (0.22)
Dosewallips	1972 - 2002	0.96 (0.90-1.04)	1.25 (0.94-1.63)	1.17 (0.24)
Duckabush	1968 - 2002	0.91 (0.87-0.96)	1.14 (0.96-1.36)	1.1 (0.17)
Hamma Hamma	1968 - 2002	0.90 (0.86-0.94)	1.20 (1.04-1.40)	1.3 (0.19)
Jimmycomelately	1974 - 2002	0.88 (0.84-0.93)	0.82 (0.64-1.03)	0.85 (0.16)
Lilliwaup	1971 - 2002	0.88 (0.83-0.92)	1.00 (0.74-1.37)	1.19 (0.44)
Salmon/Snow	1974 - 2002	0.99 (0.94-1.03)	1.24 (1.12-1.37)	1.23 (0.10)
Union	1974 - 2002	1.08 (1.05-1.12)	1.10 (1.00-1.22)	1.15 (0.10)

[1]Estimates of the fraction of hatchery fish are available only for the combined Quilcene and Salmon/Snow populations for the years 1995-2000.

Updated information on potential threats

The Puget Sound TRT (unpublished data) has estimated annual fishery exploitation rates for each summer-run chum salmon population in the ESU (Table E.2.1.4). Exploitation rates are calculated as the percentage of the total return that is caught in fisheries (i.e., total return = catch

+ broodstock take + escapement). The estimated numbers of adults harvested (i.e., catch) from Washington and Canadian fisheries are supplied by the co-managers (Nick Lampsakis, PNPTT, pers. comm.). Catch data are available for Hood Canal summer-run chum salmon from 1974 to present.

Table E.2.1.4 Average annual exploitation rates on populations of Hood Canal summer-run chum salmon during three time periods within the period 1974 – 2002. (data source: Puget Sound TRT and WDFW and PNPTT co-managers, N. Lampsakis, pers. comm.).

Population	**1974-1978 mean exploitation rate (%)**	**1979-1997 mean exploitation rate (%)**	**1998-2002 mean exploitation rate (%)**
Combined Quilcene	28	64	13
Lilliwaup	55	43	3
Dosewallips	15	34	3
Duckabush	15	34	3
Hamma Hamma	15	34	3
Jimmycomelately	8	17	1
Union	56	43	5
Salmon/Snow	11	18	1
Mean	25	36	4
Median	15	34	3
Anderson	13	34	extinct
Big Beef	15	10	extinct
Dewatto	55	37	extinct
Tahuya	56	39	extinct
Mean	35	30	
Median	35	36	

Exploitation rates on the eight extant Hood Canal summer-run chum salmon populations averaged 25% (median = 15%; range 8%-56%) in the earliest 5 years of data availability (1974-1978). The annual exploitation rates increased in the 1980s as a result of increased coho fisheries in the area, and they have since dropped to an average of 4% (median = 3%; range 1%-13%) in the most recent 5-year period, 1998-2002 (Table E.2.1.4). The most intensive harvest occurred on Hood Canal summer-run chum salmon during the period 1979-1991, when the total exploitation rate on the aggregate of Hood Canal summer-run stocks reached up to 81% in 1989 (WDFW and most recent run reconstruction from N. Lampsakis, PNPTT). During the high harvest years (1979-1991), exploitation rates on the eight extant individual summer-run chum salmon populations averaged 47% (median = 44%; range 21%–86%).

Estimates of hatchery strays to Hood Canal tributaries have been made only recently, coinciding with the instigation of hatchery programs to supplement summer-run chum salmon spawning on some streams. Releases of hatchery fish in the tributaries began in 1992 for the Big Quilcene and Salmon Rivers, so estimates of returning adult hatchery fish presently are available only for those streams (Table E.2.1.5). The marking of hatchery-origin fish has begun recently

in a number of streams (fin clips began in Quilcene in 1997, otolith marks: 1992 in Salmon Creek, 1997 in Lilliwaup, Hamma Hamma; 1998 in Big Beef Creek; 1999 in Chimacum and Jimmycomelately creeks; 2000 in Union River). Therefore, distinguishing hatchery-produced from naturally-born summer-run chum salmon will not be possible in most Hood Canal streams until 2001 at the earliest.

Table E.2.1.5. Average estimated annual returns of hatchery summer-run chum salmon to the spawning grounds of extant populations of summer-run chum salmon in Hood Canal (WDFW and PNPTT 2000 & 2001; Puget Sound TRT, unpublished data).

Population	**Year that supplementation program started with broodstock takes**	**Average annual hatchery return to stream (min-max)** [1]	**Hatchery return years**
Combined Quilcene	1992	941 (241 – 1619)	1995 - 2002
Dosewallips	None	NA	
Duckabush	None	NA	
Hamma Hamma	1998	NA	
Jimmycomelately	1999	NA	
Lilliwaup	1992	NA	
Salmon/Snow	1992	78 (2 – 319) [2]	1995 - 2002
Union	2000	NA	

[1] Estimated for Salmon River only.

Information on recent releases of hatchery juvenile summer-run chum salmon into Hood Canal streams is reported in Table E.2.1.6. Average annual juvenile summer-run chum salmon releases in streams receiving hatchery fish ranged from 15,000 – 320,000 (average = 92,000) juveniles per year between 1993 and 2001. The SSHAG group identified all hatchery stocks of Hood Canal summer-run chum salmon as category “1a” or “1b” (Appendix E.5.1).

Table E.2.1.6. Numbers of hatchery-origin juvenile summer-run chum salmon released into Hood Canal streams from 1993-2001. (B. Waknitz, unpublished data)

Watershed	Dates	Hatchery	Stock	Release Site	Total	Annual Mean
Salmon Creek	1995-2001	Salmon Creek	Salmon Creek	SalmonCreek	366,743	52,391
Jimmycomelately Creek	2000-2001	Jimmycomelately Creek	Jimmycomelately Creek	Jimmycomelately Creek	29,780	14,890
Chimacum Creek	1999-2001	Chimacum Creek	Salmon River	Chimacum Creek	248,148	82,716
Big Quilcene River	1993-2001	Quilcene NFH	Big Quilcene River	Big Quilcene River	2,918,878	324,319
Hamma Hamma River	1998-2001	Hood Canal	Hamma Hamma	John Creek	121,000	30,250
Lilliwaup Creek	1995-1997	Long Live the Kings Lilliwaup	Lilliwaup Creek	Lilliwaup Creek	93,600	31,200
Big Beef Creek	1997-2001	Big Beef Creek	Big Quilcene River	Big Beef Creek	621,332	124,266
Union River	2001	Hood Canal	Union River	Union River	75,876	75,876

Additional potential threats to Hood Canal summer-run chum salmon include negative interactions with hatchery fish (fall chinook, coho, pink, and fall chum salmon) through predation, competition and behavior modification, or disease transfer. The Hood Canal Summer-run Chum Salmon Conservation Initiative reports annually on the predicted risks associated with each of the hatchery species on summer-run chum salmon (WDFW and PNPTT 2000 and 2001). In the original report, the co-managers summarized what they considered to be the most important historical factors for decline for Hood Canal summer-run chum salmon (Table E.2.1.7). Specific mitigation measures have been identified for those hatchery programs deemed to pose a risk to summer-run chum salmon, and most of the mitigation measures had been implemented by 2000. In addition, some programs have been discontinued.

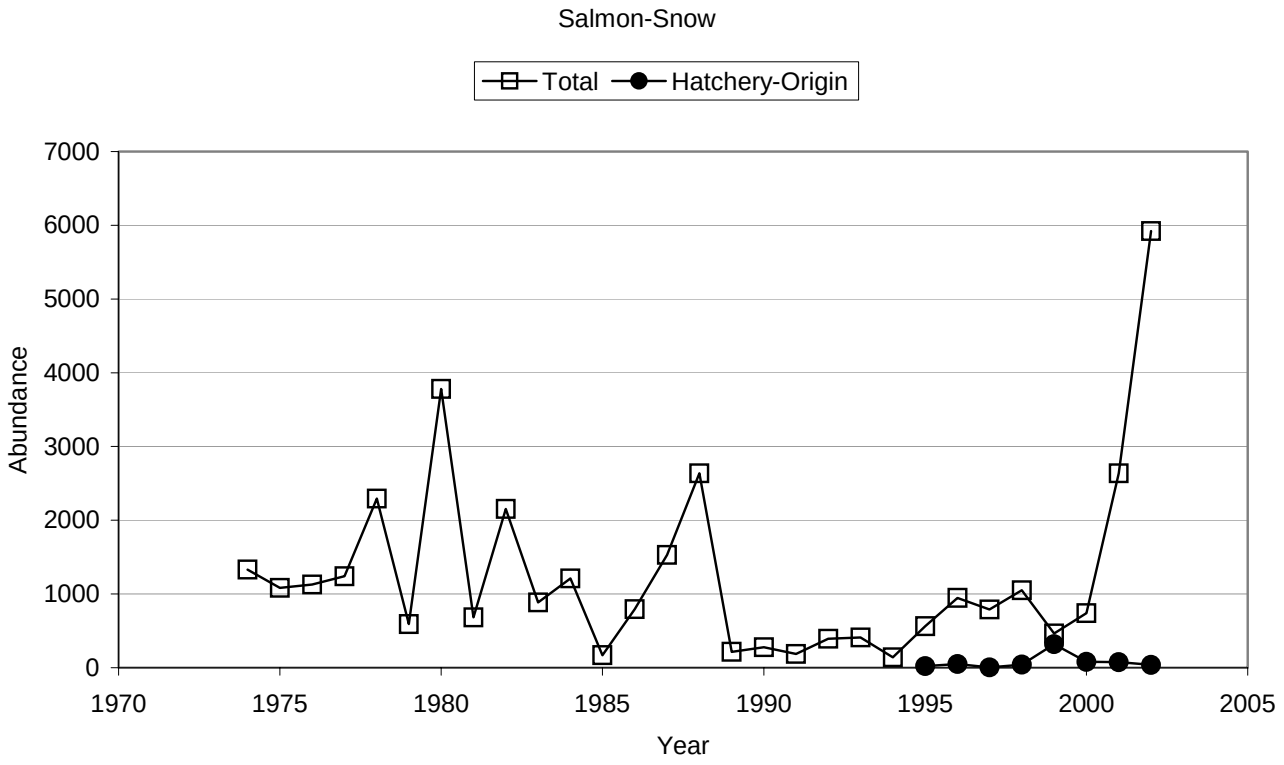
Predation on summer-run chum salmon by marine mammals in Hood Canal has been monitored by WDFW since 1998. The most recent results from these studies estimate that a few harbor seals are killing hundreds of summer-run chum salmon each year (WDFW and PNPTT 2001). Estimates of seal predation ranged from 2% to 29% of the summer-run chum salmon returning to each river annually.

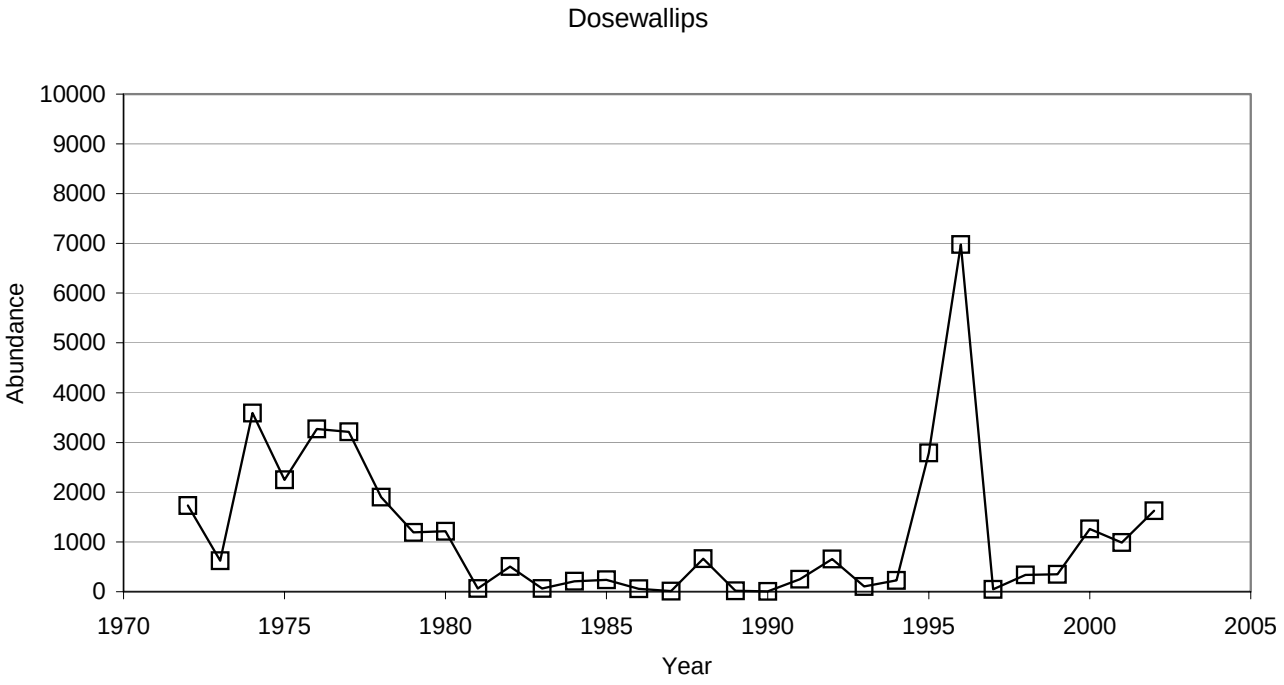
New activities related to mitigating and improving degraded habitat quality in Hood Canal are reported in the Supplemental Report No. 3 under the co-managers' Summer-run Chum salmon Conservation Initiative (WDFW and PNPTT 2001). Such activities include new shoreline management rules issued by Washington Department of Ecology (but no resulting change in shoreline master programs yet), Jefferson County improved some development codes under the Growth Management Act, Clallam County provided limited improvements in upgrading its Critical Areas Ordinance in 1999, and several habitat improvement projects have been funded by the Washington State Salmon Recovery Funding Board. The BRT did not attempt to estimate the collective impacts of these projects on the status of Hood Canal summer-run chum salmon.

Table E.2.1.7. Ratings of region-wide historical factors for decline of summer-run chum salmon in Hood Canal and Strait of Juan de Fuca streams. Impact ratings: +++ Major, ++Moderate, +Low or not likely, and **?** Undetermined (ratings from WDFW and PNPTT 2000).

Factor		**Hood Canal**	**Strait of Juan de Fuca**
Climate	Ocean conditions	**?**	**?**
	Estuarine conditions	**?**	**?**
	Freshwater conditions	++	+++
Ecological Interactions	Wild fall chum salmon	+	+
	Hatchery fall chum salmon	+**?**	+
	Other salmonids (including hatchery)	++	+
	Marine fish	+	+
	Birds	+	+
	Marine mammals	+	+
Habitat	Cumulative impacts	+++	+++
Harvest	Canadian pre-terminal catch	+	++
	U.S. pre-terminal catch	+	+
	Terminal catch	+++	+

Figure E.2.1.1. Hood Canal summer-run chum annual salmon spawner abundance vs. year by population





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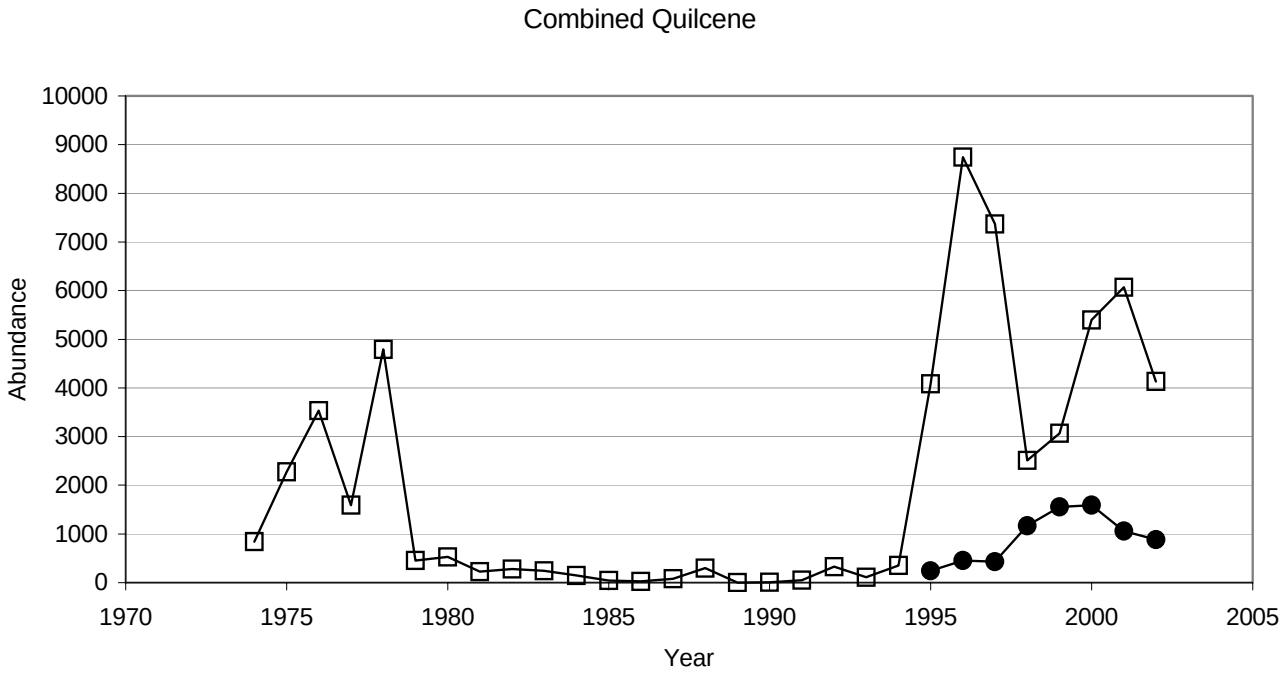

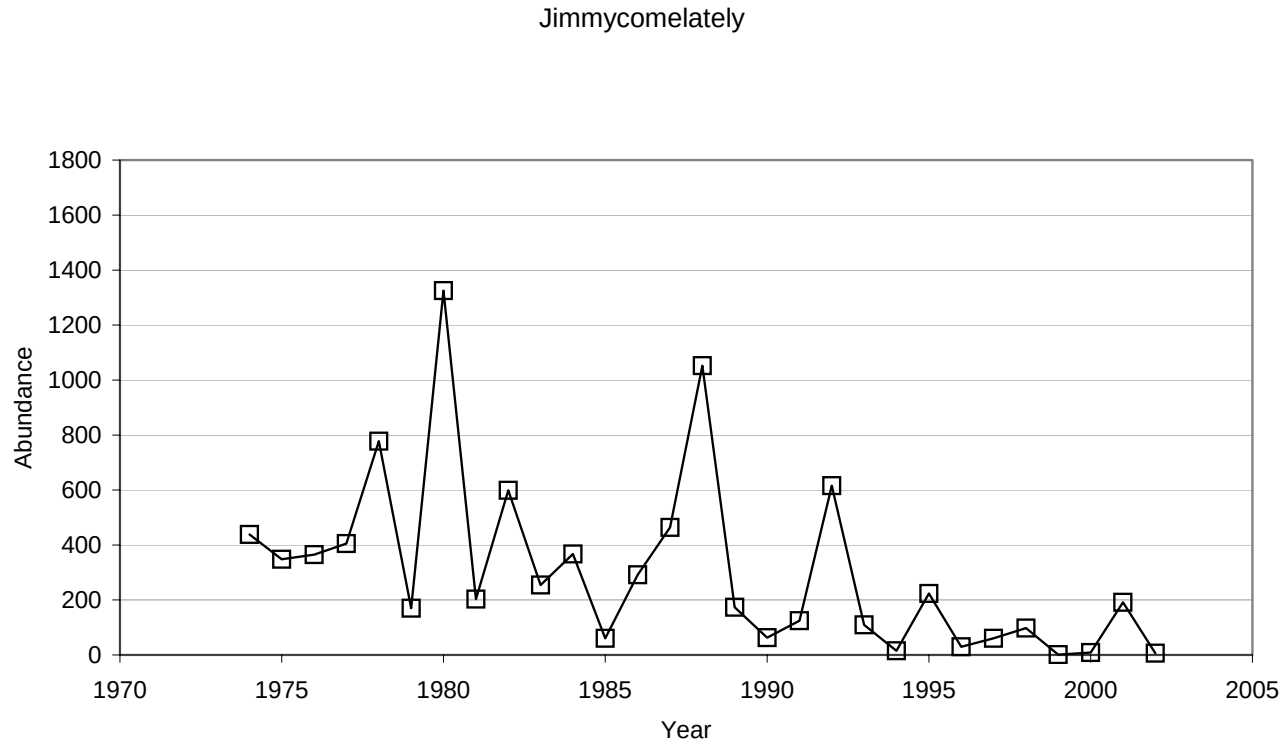

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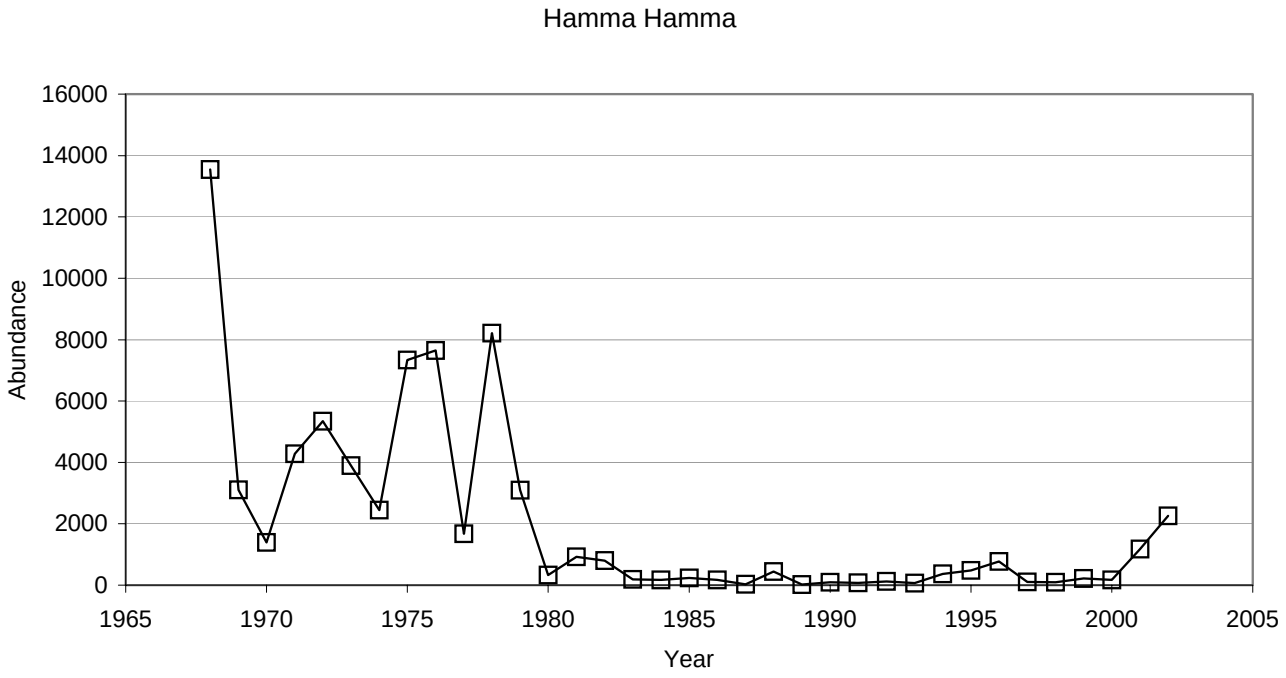

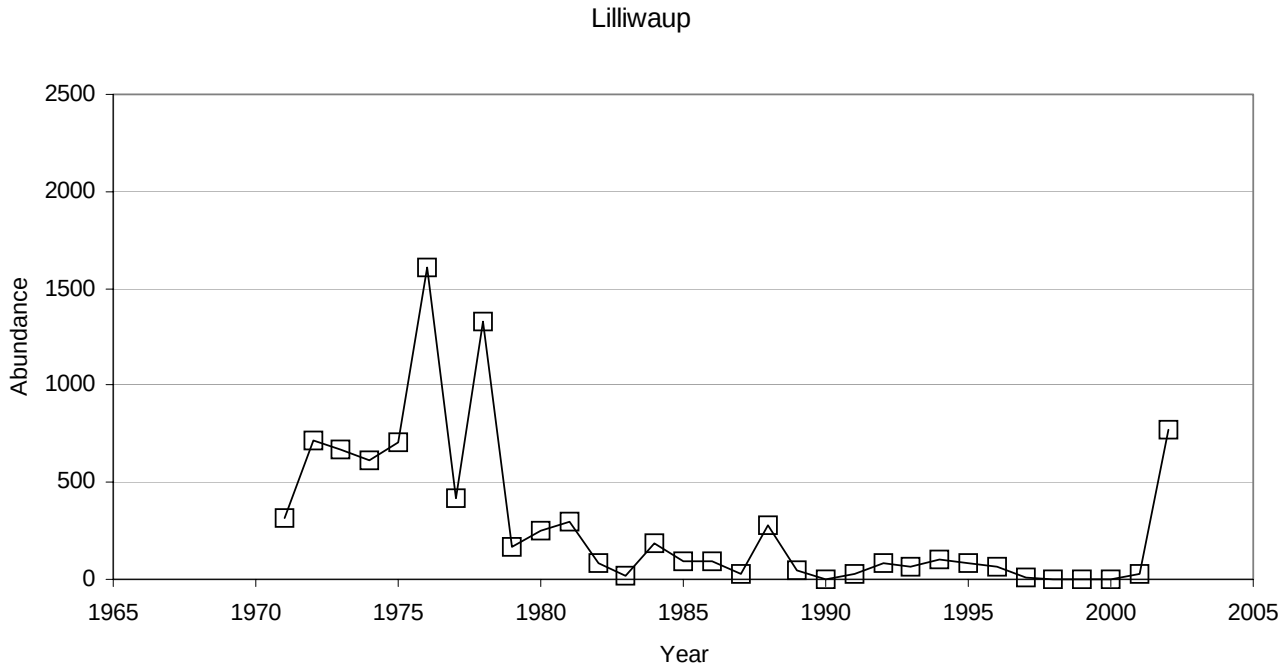

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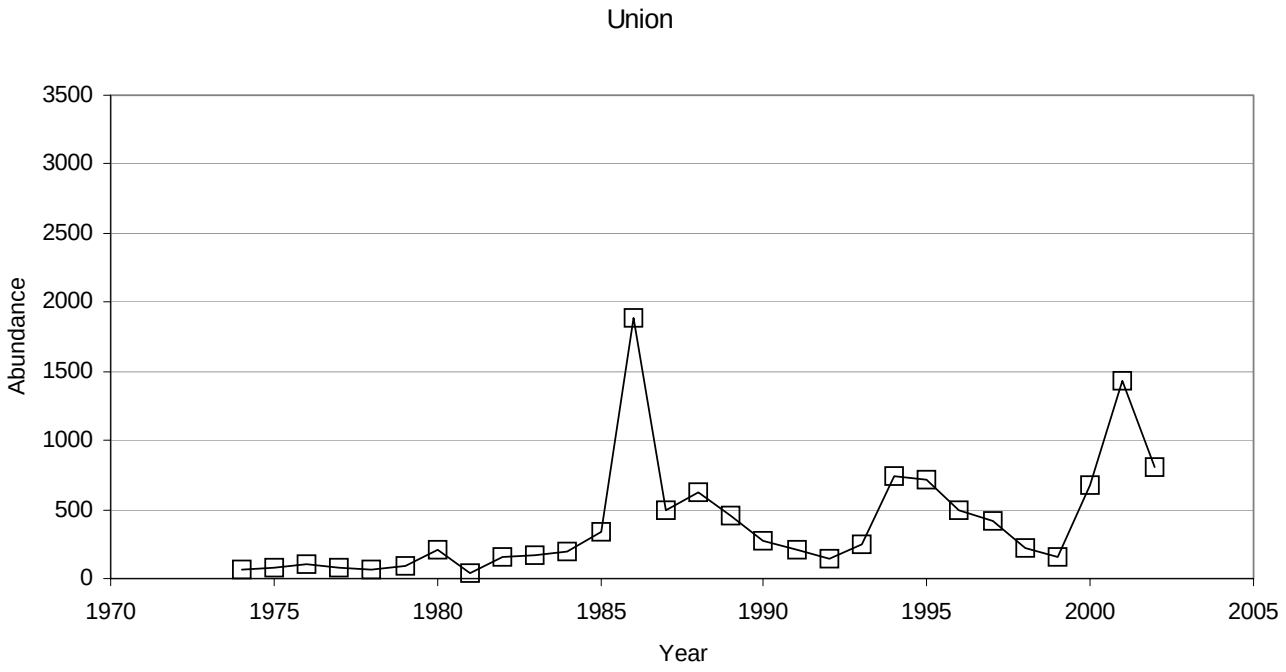
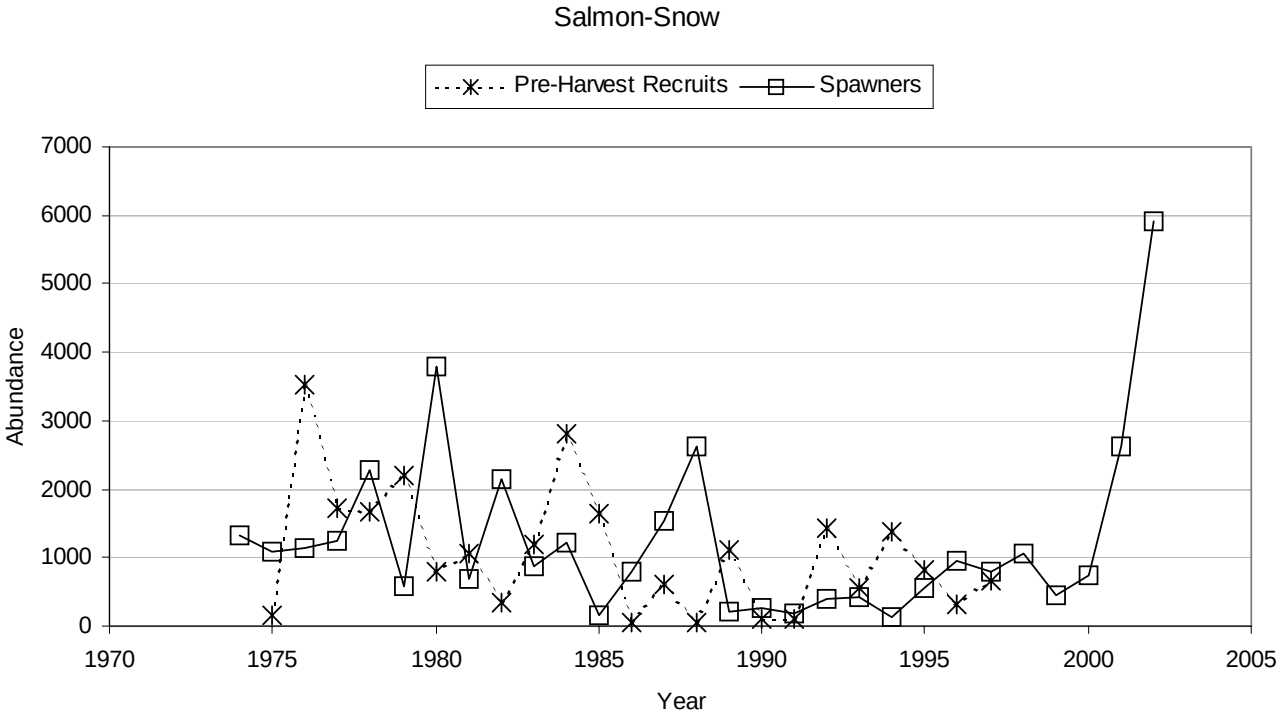


Figure E.2.1.2. Hood Canal summer-run chum recruit and spawner abundance vs. year by population



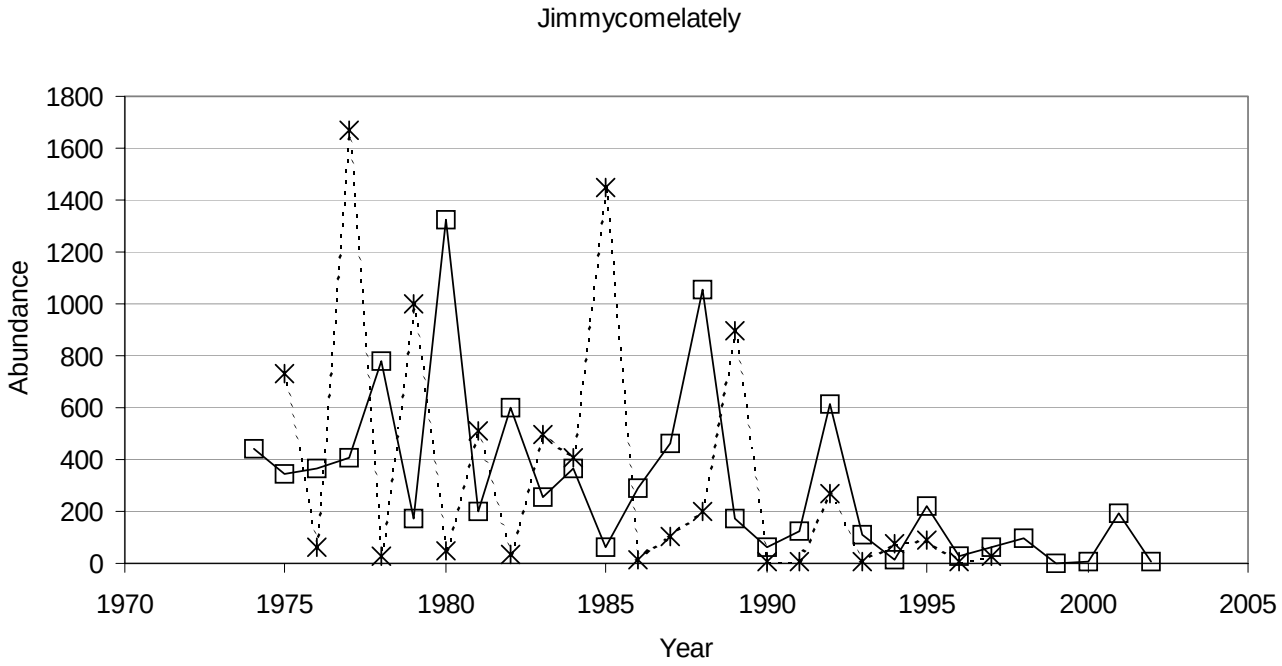
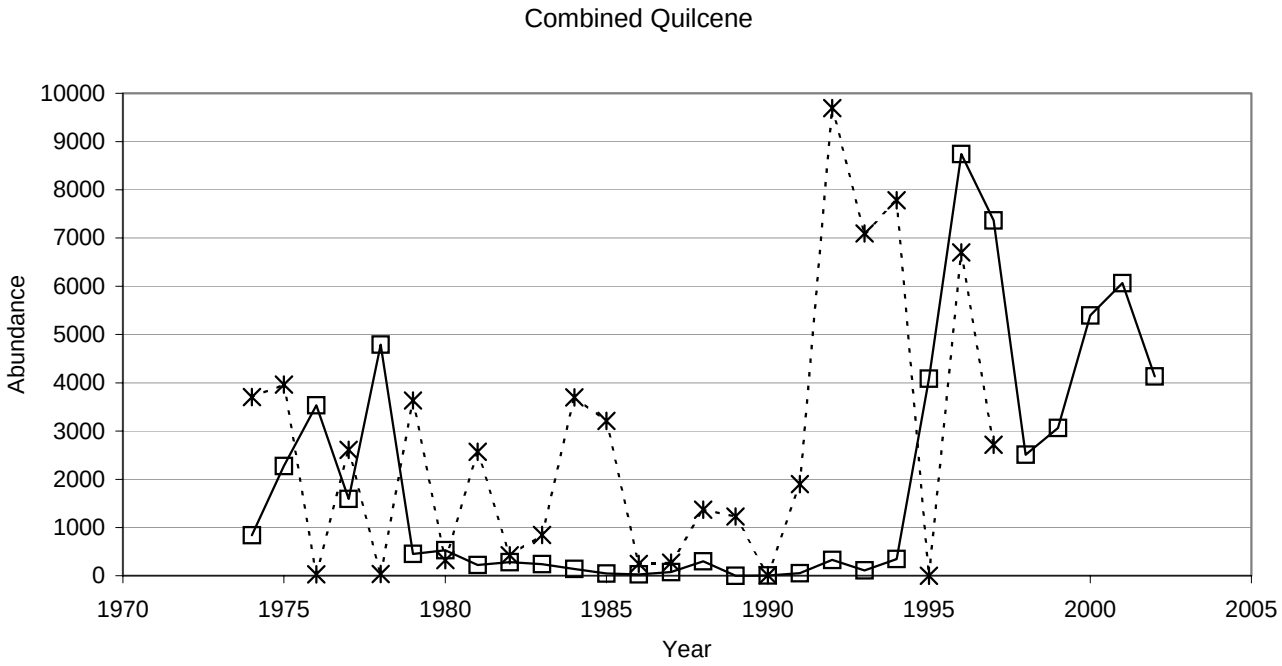


Figure E.2.1.2. (cont.)



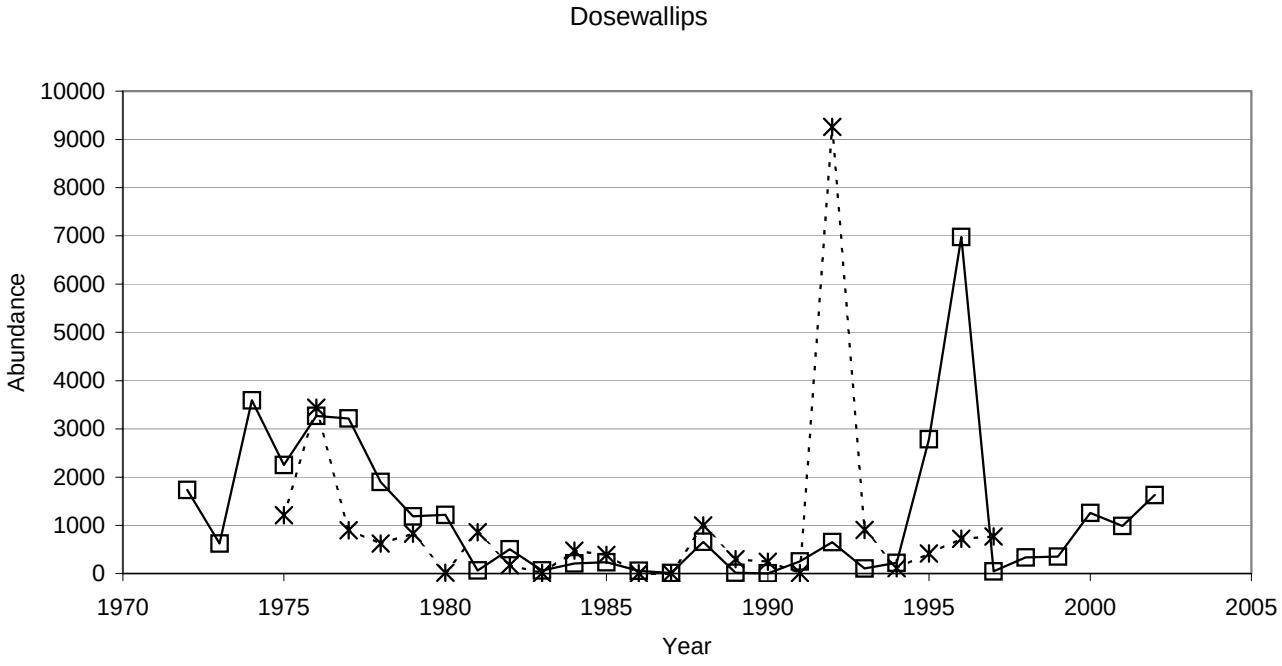
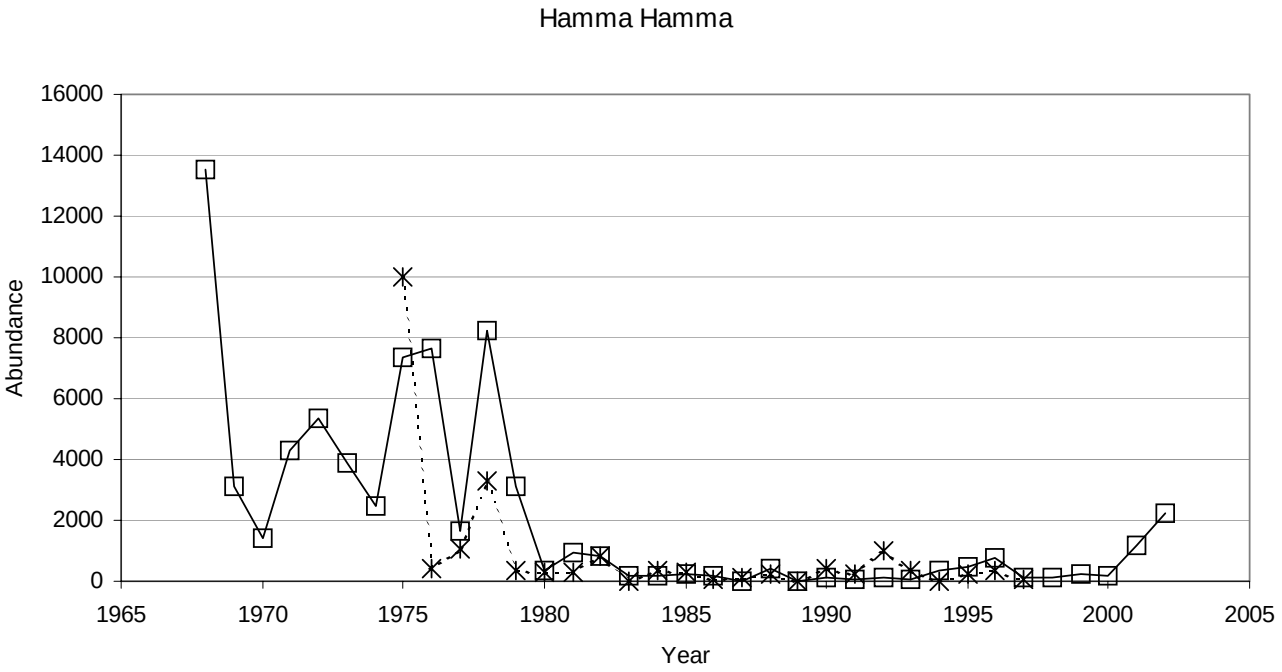


Figure E.2.1.2. (cont.)



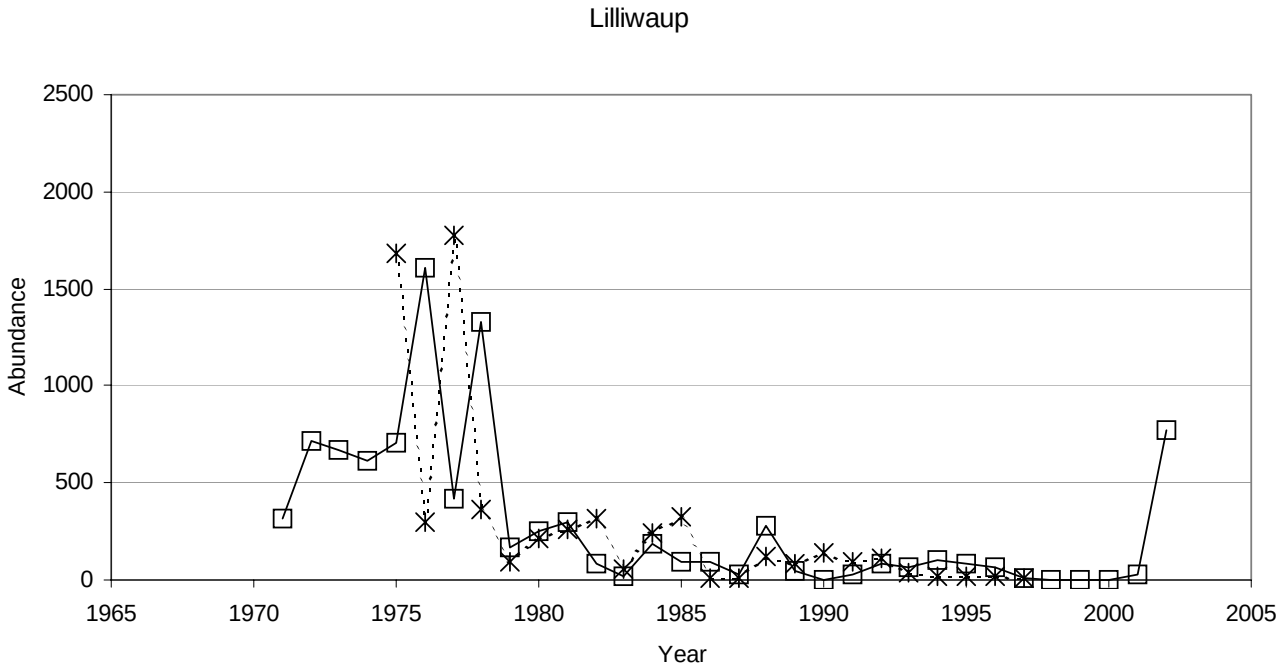


Figure E.2.1.2. (cont.)